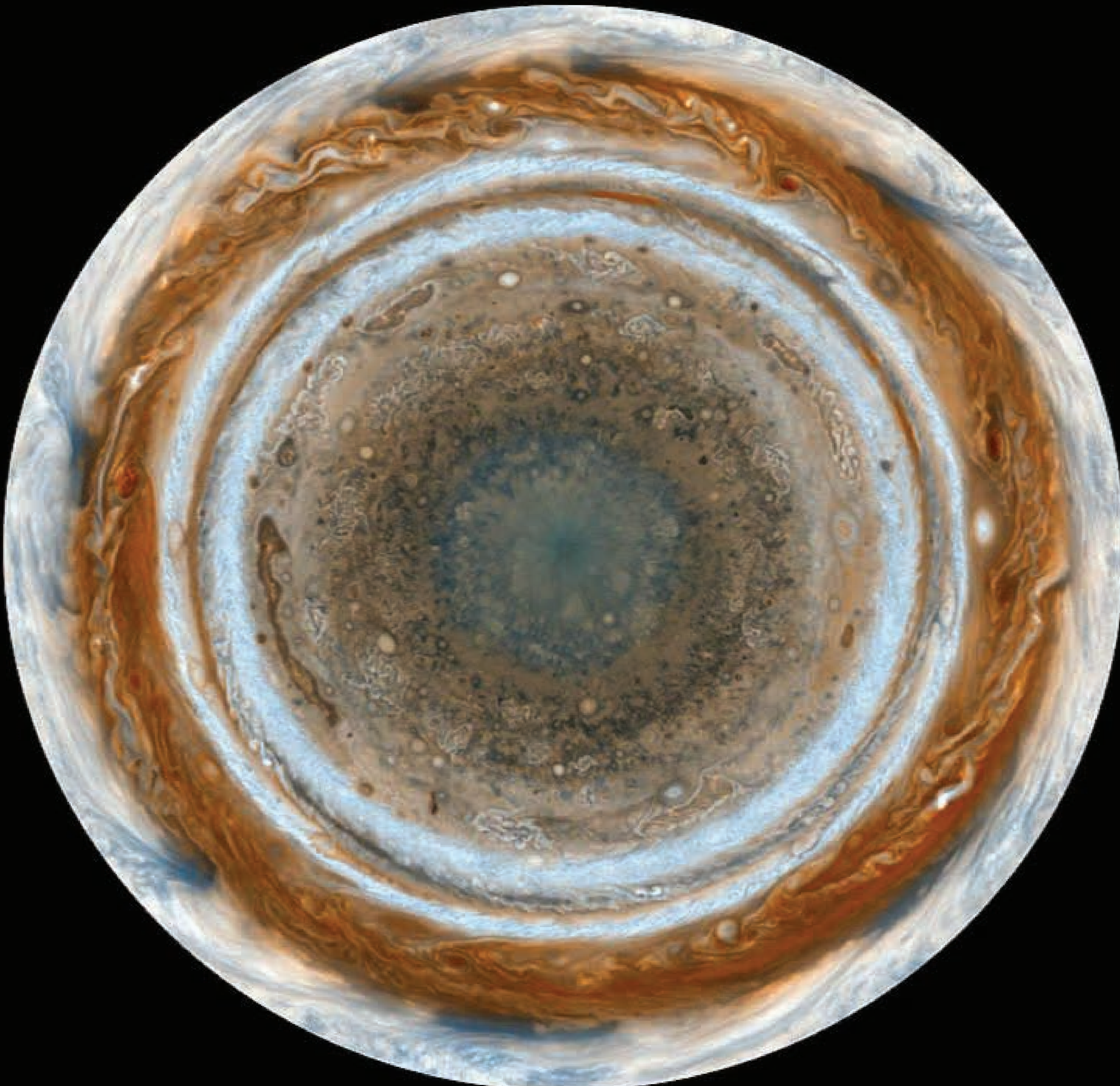
# Juno Math: Exploring Jupiter's Polar Regions



On December 8, the Cassini mission enroute to Saturn took a series of 58 images of the polar regions of Jupiter from a distance of 1.5 million kilometers. This image shows the combined images for the North Polar Region at a resolution of 120 km/pixel. Although previous missions such as Galileo had taken thousands of images of Jupiter at much higher resolutions of 30 km/pixel, their equatorial orbits did not provide access to the Polar Regions. The arrival of the Juno mission on July 4, 2016 will, for the first time, place a spacecraft in a polar orbit and provide spectacular imagery of selected areas in the north and south poles of Jupiter from distances as close as 4,300 km from the Jovian cloud tops.

The table below provides information about previous NASA missions that have provided images of Jupiter's poles, and compares the resolution of the images along with their closest approach distances. Only Pioneer 11 and Cassini were able to image the Jovian Polar Regions.

| Spacecraft | Year | Camera Aperture | Closest Approach | Resolution |
|---|---|---|---|---|
| Pioneer 11 | 1979 | 2.3 cm | 1 million km | 500 km/pixel |
| Voyager 1 | 1979 | 6 cm | 9 million km | 160 km/pixel |
| Voyager 2 | 1979 | 6 cm | 1.5 million km | 14 km/pixel |
| Galileo | 1995 | 17 cm | 1.5 million km | 30 km/pixel |
| Cassini | 2000 | 20 cm | 10 million km | 120 km/pixel |
| JunoCam | 2016 | 0.4 cm | 4,300 km | 15 km/pixel |
| Hubble | 1995-2016 | 2.4 meters | 600 million | 120 km/pixel |

**Problem 1** – From the data in the table, convert the resolution of each camera at the indicated distances to an equivalent resolution at a reference distance of 4,300 km, then rank the missions in terms of the relative resolutions of each imaging system from highest to lowest in meters per pixel.

**Problem 2** – Why do you think that such a small camera system was used on the Juno mission?

**Problem 1 -** *From the data in the table, convert the resolution of each camera at the indicated distances to an equivalent resolution at a distance of 4,300 km, then rank the missions in terms of the relative resolutions of each imaging system from highest to lowest in meters per pixel.*

Answer: The resolution at a specific distance can be found from a simple proportion. For example, in the case of Pioneer 11,

New resolution =500 km/pixel x ( 4,300 km/ 1 million km) = 2,150 **m/pixel**

| Spacecraft | Year | Camera Aperture | Closest Approach | Old Resolution | **New Resolution** |
|---|---|---|---|---|---|
| Hubble | 1995-2016 | 2.4 meters | 600 million | 120 km/pixel | **1 m/pix** |
| Voyager 2 | 1979 | 6 cm | 1.5 million km | 14 km/pixel | **40 m/pix** |
| Cassini | 2000 | 20 cm | 10 million km | 120 km/pixel | **52 m/pix** |
| Voyager 1 | 1979 | 6 cm | 9 million km | 160 km/pixel | **76 m/pix** |
| Galileo | 1995 | 17 cm | 1.5 million km | 30 km/pixel | **86 m/pix** |
| Pioneer 11 | 1979 | 2.3 cm | 1 million km | 500 km/pixel | **2150 m/pix** |
| JunoCam | 2016 | 0.4 cm | 4,300 km | 15 km/pixel | **15,000 m/pix** |

**Problem 2** – *Why do you think that such a small camera system was used on the Juno mission?*

Answer: The JunoCam system had to be made small enough that its exposed optics and electrical systems would survive the extreme radiation environment of Jupiter at such a close distance. The mission goal was not to image the Jovian poles, but to use other instruments to explore the radiation environment. These instruments were protected by over 200 kg of radiation shielding, unlike the JunoCam system. The other systems in the table would not have survived the Jovian radiation environment had they come as close to the polar cloud tops as Juno. In other words, the performance of JunoCam was a 'trade off' between the ability to get the highest possible resolution images, and the other more significant scientific goals of the mission.